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Chinook Salmon Insights from Marine Ecosystem Monitoring in Southeast Alaska

Joe Orsi

2012 University of Alaska Fairbanks Seminar

Juneau, Alaska on 16 November 2012

2012 Alaska Chinook Salmon Symposium

Understanding Abundance and Productivity Trends of Chinook Salmon in Alaska

Anchorage, Alaska on 23 October 2012

Chinook salmon disaster declaration...

July 2012

Alaska Governor Sean Parnell requested from the Federal Government a determination of a commercial fishery failure due to a resource disaster under the Magnuson-Stevens Fishery Conservation and Management Act of 1976 (MSA) for certain Alaska Chinook fisheries

August 2012

ADFG researchers met informally with NOAA researchers in Juneau to assess the state of knowledge of Chinook in marine ecosystems

September 2012

Acting Secretary of Commerce Rebecca Blank determined a commercial fishery failure under the Interjurisdictional Fisheries Act of 1986 of the MSA...for the Yukon (2011, 2012, and 2013), Kuskokwim (2011 and 2012), and for Cook Inlet (2012).

October 2012

Alaska Department of Fish and Game hosted a Chinook Salmon Symposium in Anchorage to address topics of concern raised under a recent "gap analysis" with guest speakers, an expert panel, and audience (on-line) participation

http://www.adfg.alaska.gov/index.cfm?adfg=chinook_efforts_symposium.information



Seminar Outline

- 1) Provide background information on Chinook geographic distribution, life history, and Alaska harvest trends
- 2) Present the talk I gave at the 2012 Chinook Salmon Symposium
- 3) Share some “afterthoughts” on data gaps and future research since the Symposium



Everybody in Alaska loves king salmon!



Golden North Salmon Derby 1968



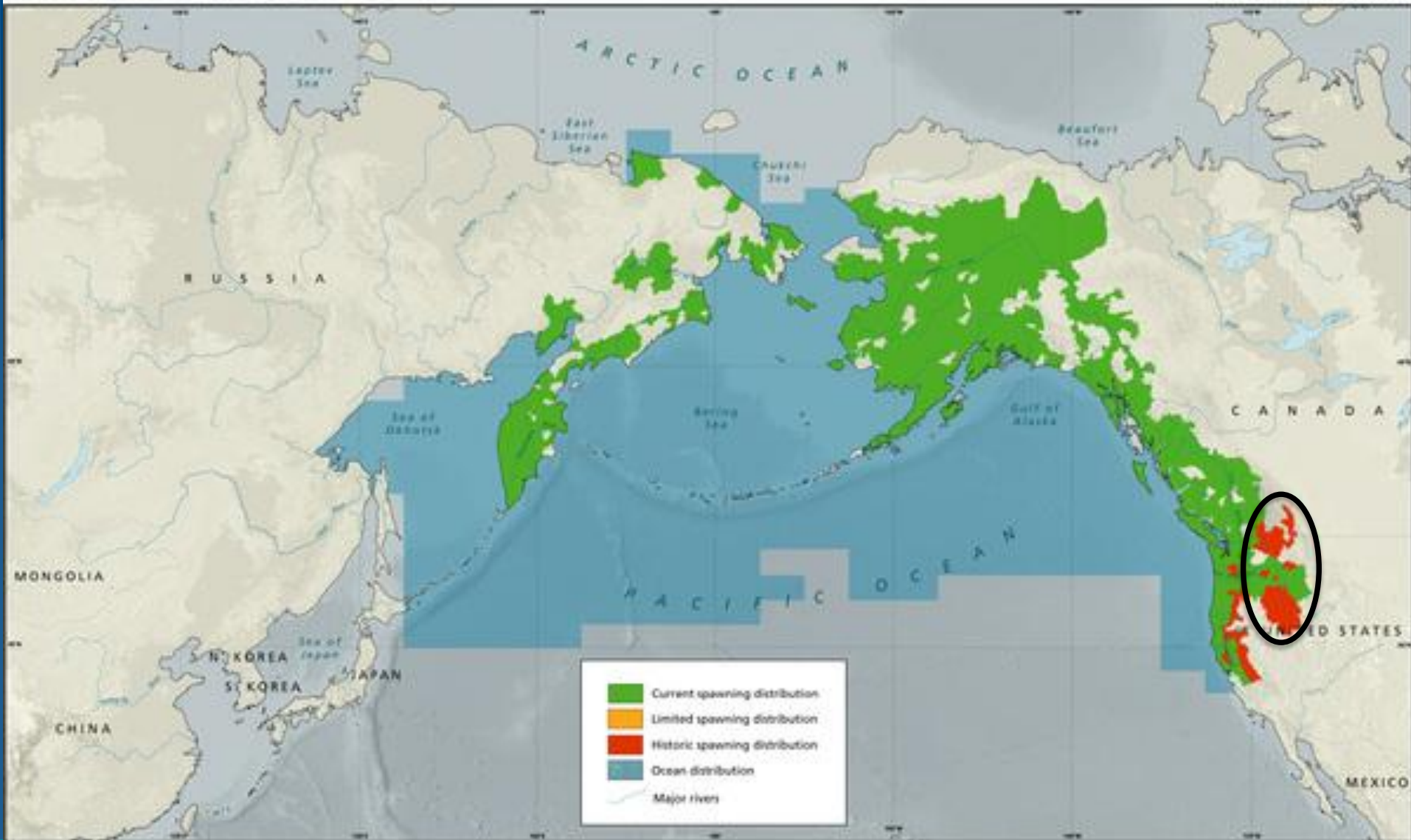
Southeast commercial salmon troller



Chinook salmon geographic distributions

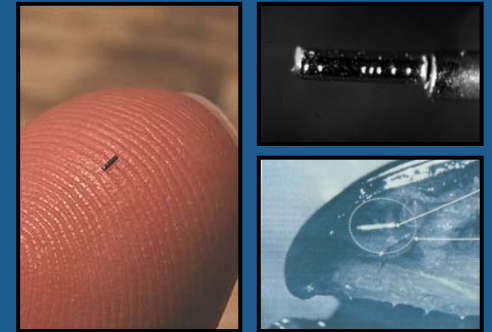
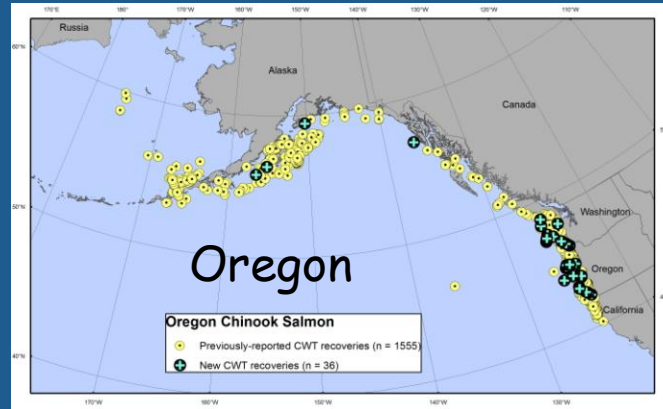
Chinook Distribution

© 2005 State of the Salmon, a joint program of Wild Salmon Center and EcoTrust

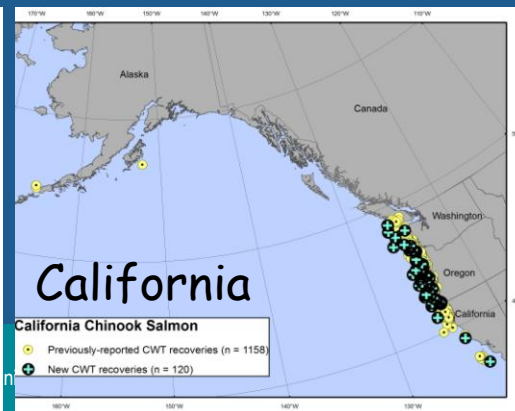
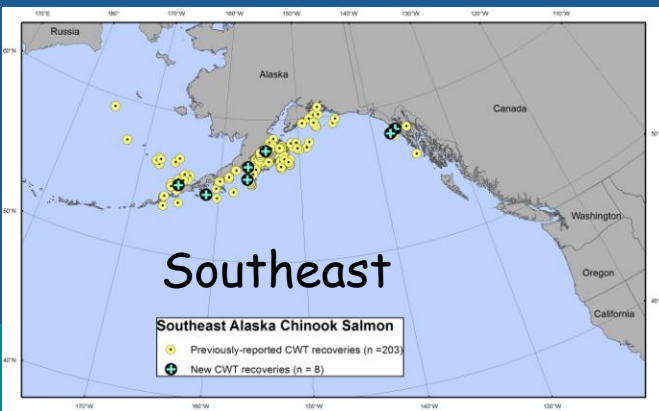


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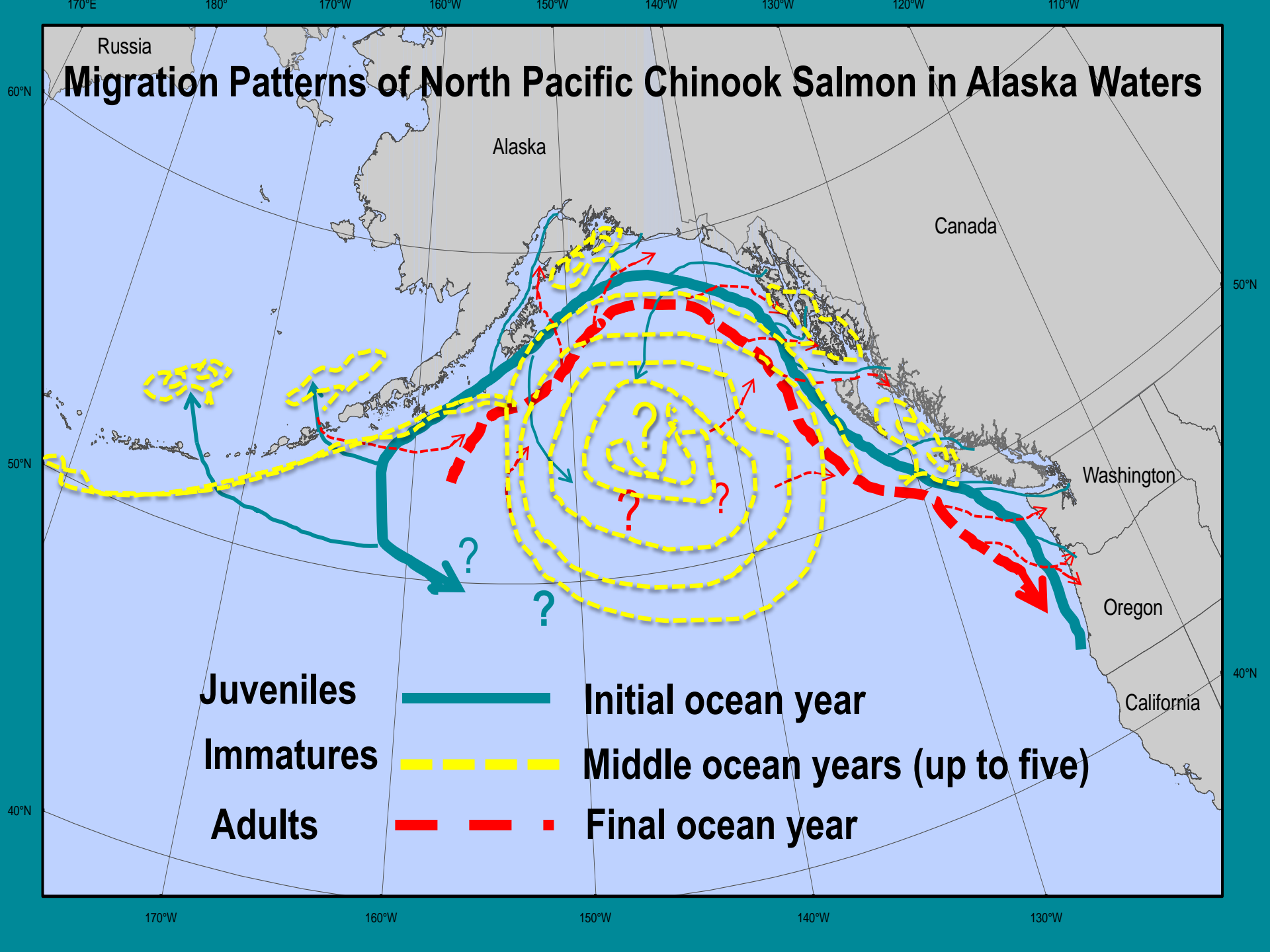
NMFS high seas recoveries of CWT Chinook 1981-2012



Data courtesy
Adrian Celewycz
CWT Mark
Coordinator
for NMFS Alaska



Migration Patterns of North Pacific Chinook Salmon in Alaska Waters



Chinook ocean age at maturity is variable & related to gender

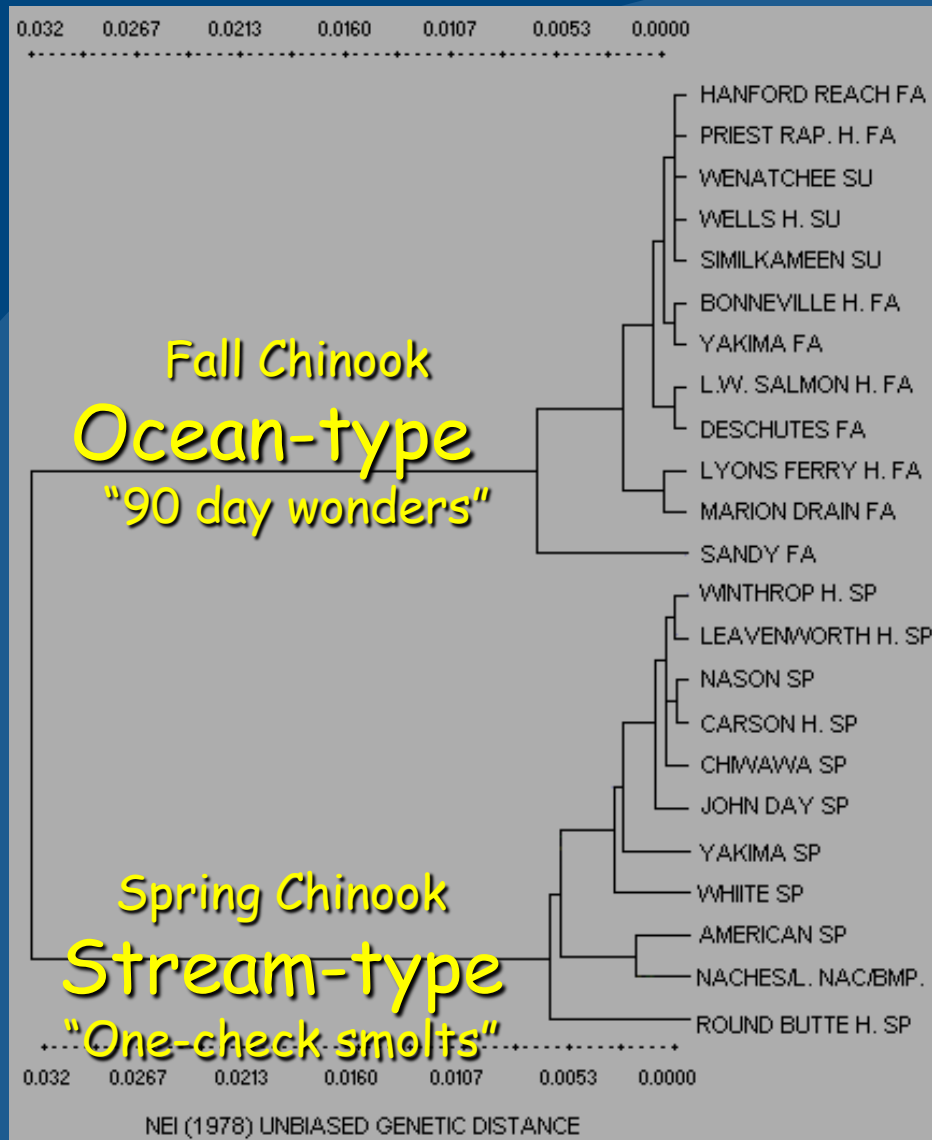


Females: ocean ages 2*, 3, 4, and 5
*rare in AK

Males: ocean ages 0*, 1, 2, 3, 4, & 5
*hatchery only



Chinook salmon freshwater life histories



Status Review for Mid-Columbia River Summer Chinook Salmon

Waknitz et al. 1995
NOAA Tech. Memo. 22

Figure 2. Genetic relationships among selected samples of Chinook salmon in the Columbia River Basin based on Nei's unbiased genetic distance (1978) and unweighted, pair-group method and arithmetic averages (UPGMA; Sneath and Sokal, 1963) for 36 loci (Marshall 1994a and b).



Coastwide Distribution and Ocean Migration Patterns of Stream- and Ocean-Type Chinook Salmon.

Healey, 1983. Can. Field. Nat

Compared to Ocean-type fish, Stream-type fish:

1. Occur in nearly 100% of runs north of 55° 20' N
2. Move offshore as juveniles more rapidly
3. Spend most of life in offshore waters

TABLE 1. Occurrence of stream-type Chinook Salmon in spawning runs to rivers along the west coast of North America. The rivers are ordered in descending latitude.

River System(s)	Approximate N. Latitude	Information Source	Percent Stream-Type
Alaska			
Yukon	60° 30'	Gilbert 1913	100
Cook Inlet	61° 30'	Yancey and Thorsteinson 1963	97-99
Taku	58° 30'	Mehan and Siniff 1962, Kissner 1973	100
Stikine	56° 40'	Kissner 1973	100
British Columbia			
Nass	55° 20'	Godfrey 1968	42
Skeena	54° 20'	Godfrey 1968	48
Kitimat	54° 0'	Canada, Fisheries and Marine Service (Unpublished Data)	12
Yakoun	53° 20'	Canada, Fisheries and Marine Service (Unpublished Data)	57
Bella Coola	52° 25'	Canada, Fisheries and Marine Service (Unpublished Data)	14
Wannock (Rivers Inlet)	51° 40'	Schutz 1975	3
Quinsam (Campbell)	50° 0'	Canada, Fisheries and Marine Service (Unpublished Data)	1
Big Qualicum	49° 25'	Canada, Fisheries and Marine Service (Unpublished Data)	0
Fraser	49° 20'	Godfrey 1968	34
Nanaimo	49° 10'	Healey Unpublished Data	5
Natinat	48° 50'	Healey Unpublished Data	1
Chemamus	48° 50'	Canada, Fisheries and Marine Service (Unpublished Data)	0
Cowichan	48° 50'	Canada, Fisheries and Marine Service (Unpublished Data)	10
Washington/Oregon			
Columbia	46° 10'	Rich 1925	22
Sixes	42° 50'	Reimers 1971	12
California			
Klamath	41° 30'	Snyder 1931	14
(Monterey Bay)	36° 40'	Snyder 1931, Rich 1925	11



Chinook age variation: Alaska to Oregon

CHINOOK SALMON SIZE AND AGE VARIATION

329

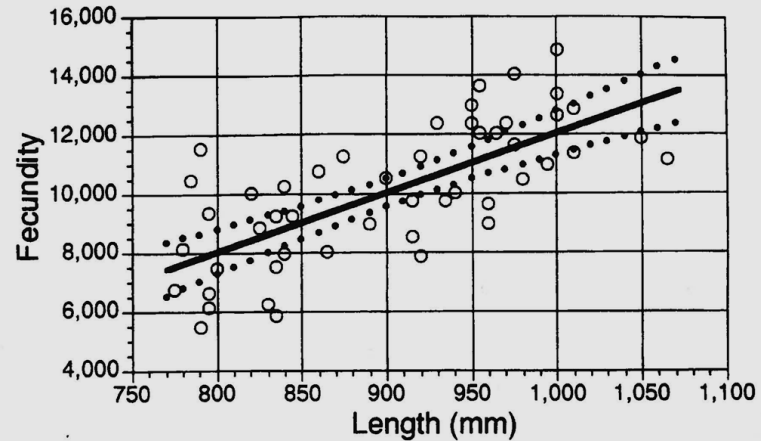
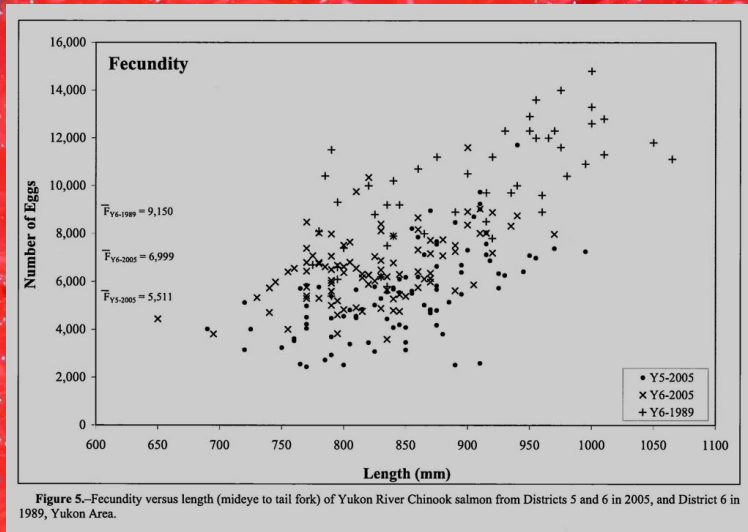
Roni and Quinn 1995, NAJFM

TABLE 1.—Age composition of chinook salmon populations from different North American rivers or areas. Number of stocks for each area is in parentheses; M is male and F is female. Central Alaska includes populations north of Prince William Sound (inclusive); southeast Alaska includes all populations south of Prince William Sound in Alaska. Regional groups do not include study populations.

River or area	Sex	Ocean-type										Stream-type					Mean marine age
		0.1	0.2	0.3	0.4	0.5	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	
Central Alaska (21)	M						0.8	21.8	31.3	36.0	4.9		0.2	2.3	2.4	0.3	3.3
	F							1.6	18.5	62.3	11.5		0.0	0.3	3.9	1.8	3.9
Kendai River	M						0.4	14.4	17.7	58.8	8.2			0.4			3.6
	F							3.1	8.7	79.1	8.9	0.1	0.1				3.9
Southeast Alaska (19)	M		2.0	0.3	0.2		15.8	30.6	30.8	19.1	0.4	0.1	0.4	0.3			2.6
	F		0.2	0.7	1.4		0.0	0.8	40.9	53.8	1.4		0.4	0.2	0.2		3.6
British Columbia (29)	M	0.5	2.9	10.7	3.2		6.7	25.9	40.6	9.3	0.1						2.7
	F		0.9	14.1	3.5	0.1	0.1	9.8	58.1	13.2	0.1		0.1				3.1
Nisankalum River	M			1.6	3.1	0.8		7.0	21.9	53.9	11.7						3.8
	F				2.1	1.1			20.3	68.4	8.0						3.9
Wannock River	M		15.6	43.3	37.8	1.1			1.1	1.1							3.3
	F			24.0	74.0	2.1											3.8
Washington (37)	M	3.0	12.8	27.8	11.9	1.6	2.3	28.5	11.9	0.1							2.6
	F		3.0	32.5	15.9	4.7	0.0	23.9	19.5	0.4							3.0
Oregon (24)	M	12.3	21.3	35.5	14.6	2.4	1.0	10.6	2.4	0.1							2.6
	F		8.4	36.7	35.1	5.9		8.4	4.2								3.3



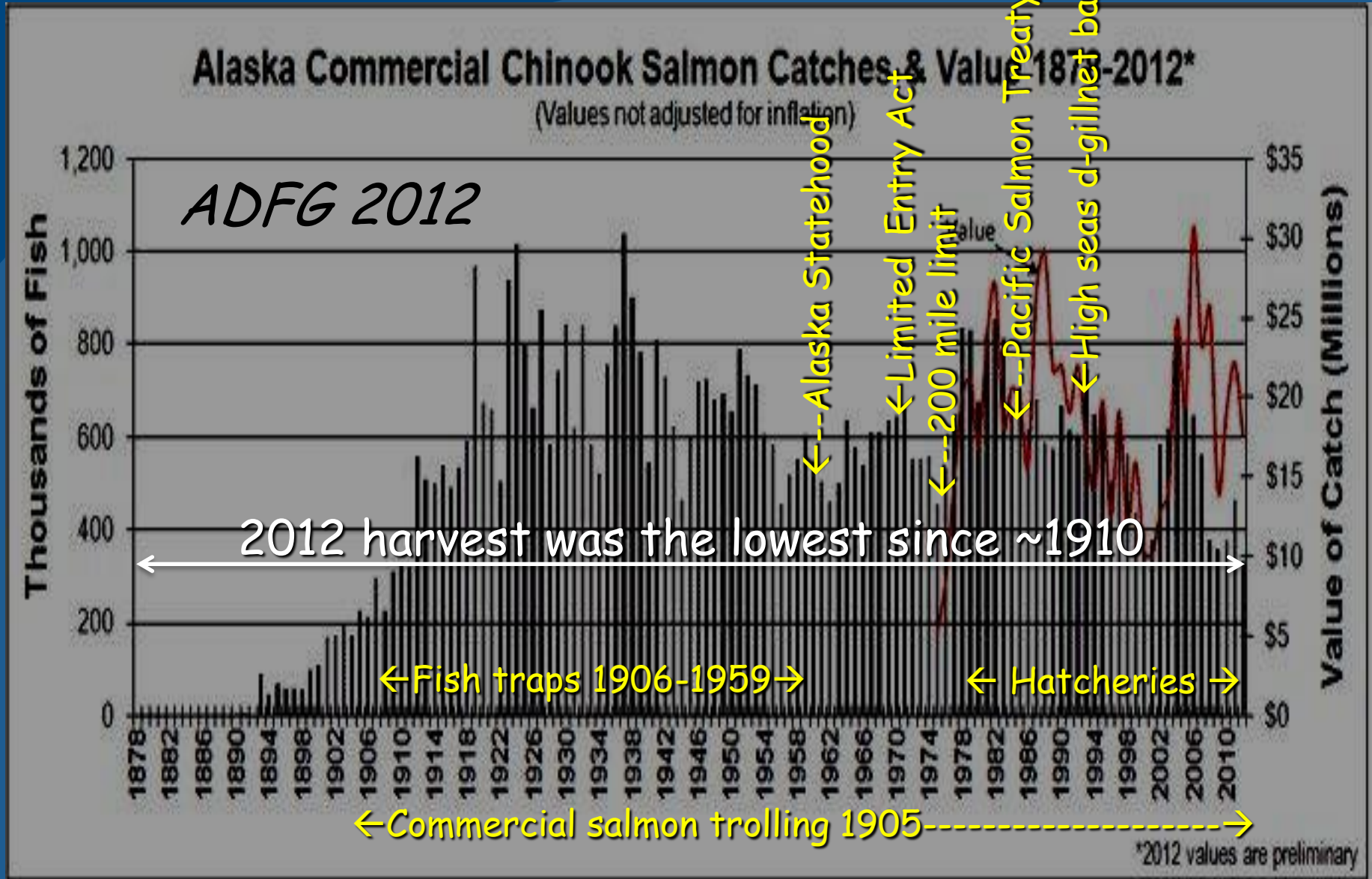
Chinook fecundity: ~2-17 K eggs



Yukon River Chinook 2-15 K eggs
Jasper and Evenson, 2006, ADFG

Tanana River Chinook 5-15 K eggs,
Older ocean age groups more fecund
Skaugstad and McCracken, 1991, ADFG

Chinook salmon commercial harvest in AK



Presentation outline

A close-up photograph of a Chinook salmon head, showing its eye, scales, and the characteristic dark spot above the eye. The fish is facing left, and the background is a soft, out-of-focus grey.

- ❖ Highlight some past research studies & insights relevant to Chinook: 1982-1996
- ❖ Review current long-term Southeast Alaska Coastal Monitoring project: 1997-2012
- ❖ Summarize selected findings on Chinook marine distribution, ecology, & production
- ❖ Identify future research needs to better understand Chinook production mechanisms

Juvenile salmon research studies 82-87



Small mesh purse seining
July-Aug of 1982-1983

- 253 seine hauls
- **38 Chinook salmon**



Salmon power trolling w/small
gear-3 regions-May/Sept/Feb
inshore/coastal - 1986-1987



- 135 charter days
- **5,838 Chinook salmon**
(539 coded-wire tags)

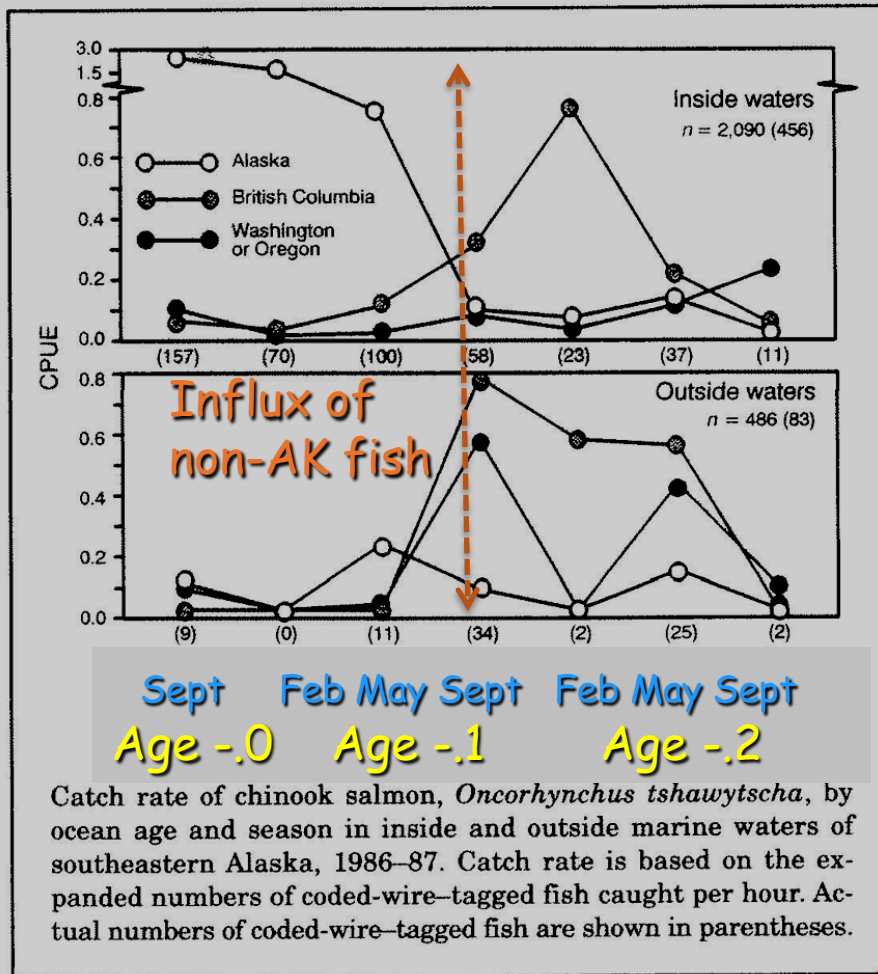


Insights from Chinook research



Marine distribution and origin of prerecruit Chinook salmon in southeastern Alaska
(Orsi and Jaenicke 1996)

- Described seasonal stock-specific distributions of AK, BC, & WA/OR fish from cwts (74 stocks)
- Identified SEAK as an important nursery area for prerecruit Chinook salmon from up to 1,800 km south



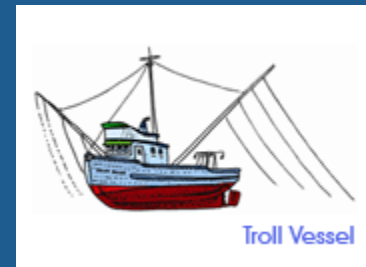
Insights from Chinook research...

Largest
Chinook
deepest

Fish shallow in
May deep in
Winter

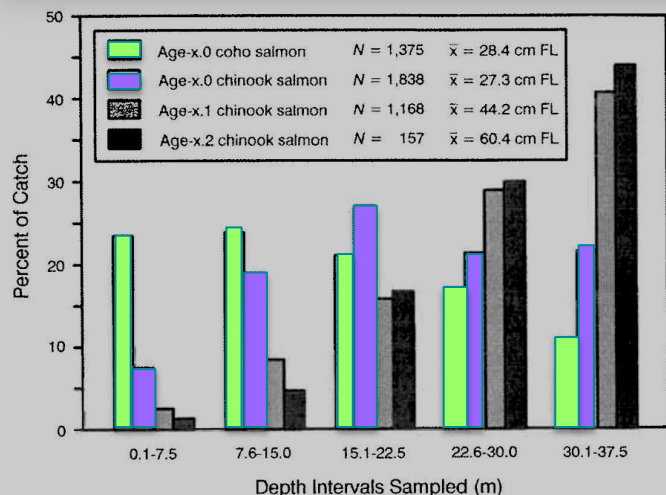
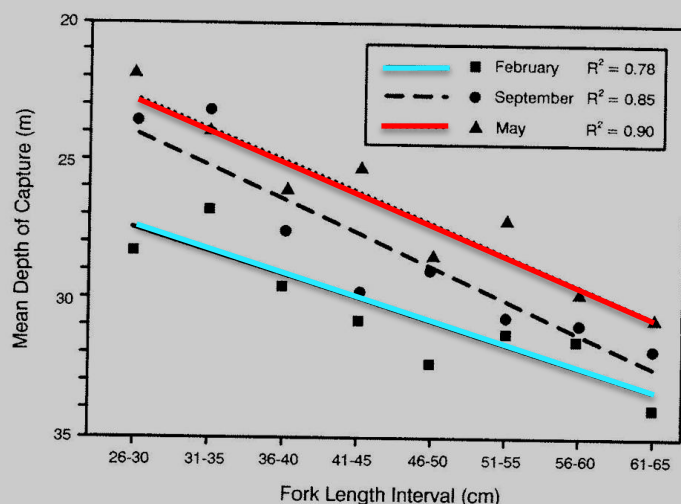
Juvenile Chinook
deeper than coho:
habitat partitioning
in September

Older Chinook
deeper



Marine vertical
distribution of
Chinook salmon and
coho salmon in
southeastern
Alaska

(Orsi and
Wertheimer 1995)



Juvenile salmon research studies 1993-2012



Two boat pair trawling
June-Aug 1993-1996

- shallow 3-m, 10 min, night
- ~225 hauls
- **20 Chinook salmon**

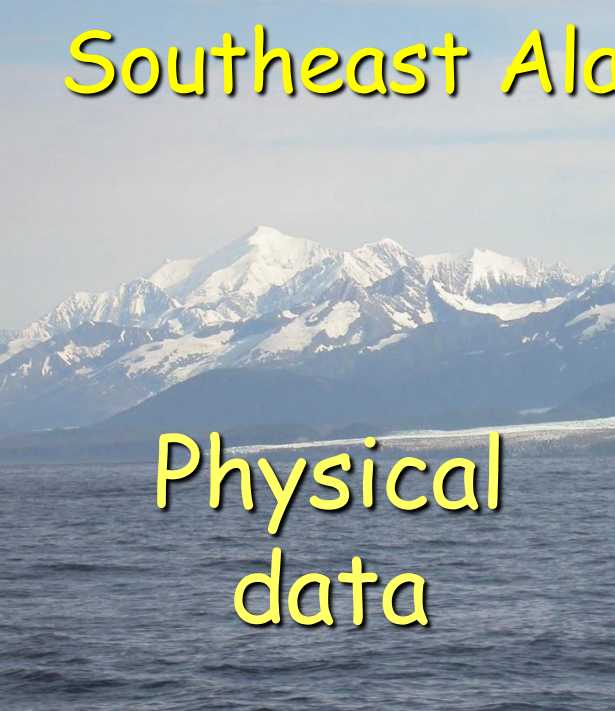


Surface rope trawling (SECM)
May-**Jun-Jul-Aug**-Sep 1997-2012

- 20-m deep, 20 min, day
- 1,382 hauls
- **1,299 Chinook salmon**



Southeast Alaska Coastal Monitoring (SECM)



Physical
data



Zooplankton
biomass/diet



Catches
(CPUE)



Pink Chum

Size & growth



Pink

Chum

Sockeye

Coho

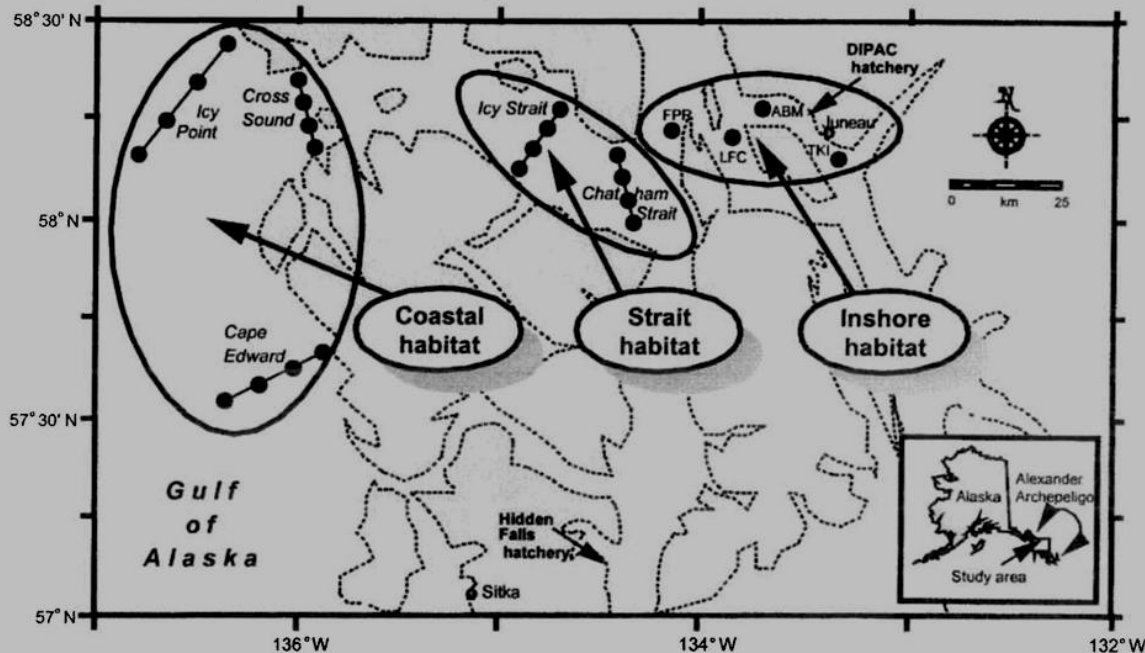
Stock comp



Predation

Seasonal distribution of juvenile salmon

Fig. 1. Stations sampled monthly in inshore, strait, and coastal marine habitats of the northern region of southeastern Alaska, May–October 1997–99. Up to 24 stations were sampled: four stations (ABM: Auke Bay Monitor, FPR: False Point Retreat, LFC: Lower Favorite Channel, TKI: Taku Inlet) in inshore habitats, two transect lines (four stations each) in strait habitats, and three transect lines (four stations each) in coastal habitats. Localities of the two primary salmon hatcheries in the region are identified: DIPAC (Douglas Island Pink and Chum) hatchery and Hidden Falls hatchery.



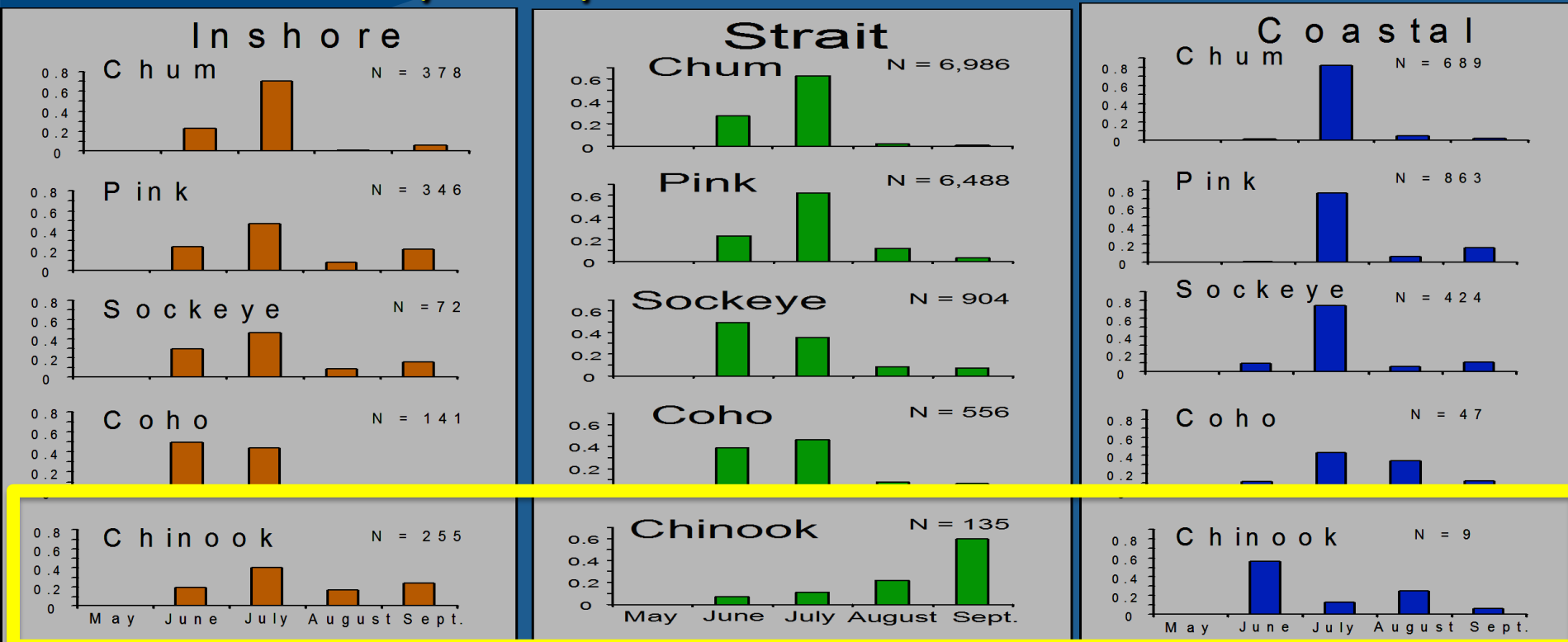
¹Reference to trade names does not imply endorsement by the National Marine Fisheries Service.

Seasonal habitat use
and early marine
ecology of juvenile
Pacific salmon in
southeastern Alaska
(Orsi et al. 2000)

Differential
habitat use by
species?

Seasonal signals
from May to
September?

Juvenile salmon distribution patterns May-September 1997-2000



Inshore (high #s)

Strait (medium #s)

Coastal (low #s)

- Inshore: distributed evenly among months
- Strait: increased from June to September
- Coastal: peaked in June, declined in later months

What is the relative abundance of Chinook compared to other epipelagic fish species?



THE
ECOLOGY
of
JUVENILE
SALMON
in the
NORTHEAST
PACIFIC
OCEAN:

*Regional
Comparisons*

Churchill B. Grimes
Richard D. Brodeur
Lewis J. Halderson
Stewart M. McKinnell

Symposium 57



Epipelagic fish assemblages associated with juvenile Pacific salmon in neritic waters of the California Current and the Alaska Current (*Orsi et al. 2007*)



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Daytime surface trawls, inshore & coastal waters,
spring/summer & summer/fall periods, 2000-2004

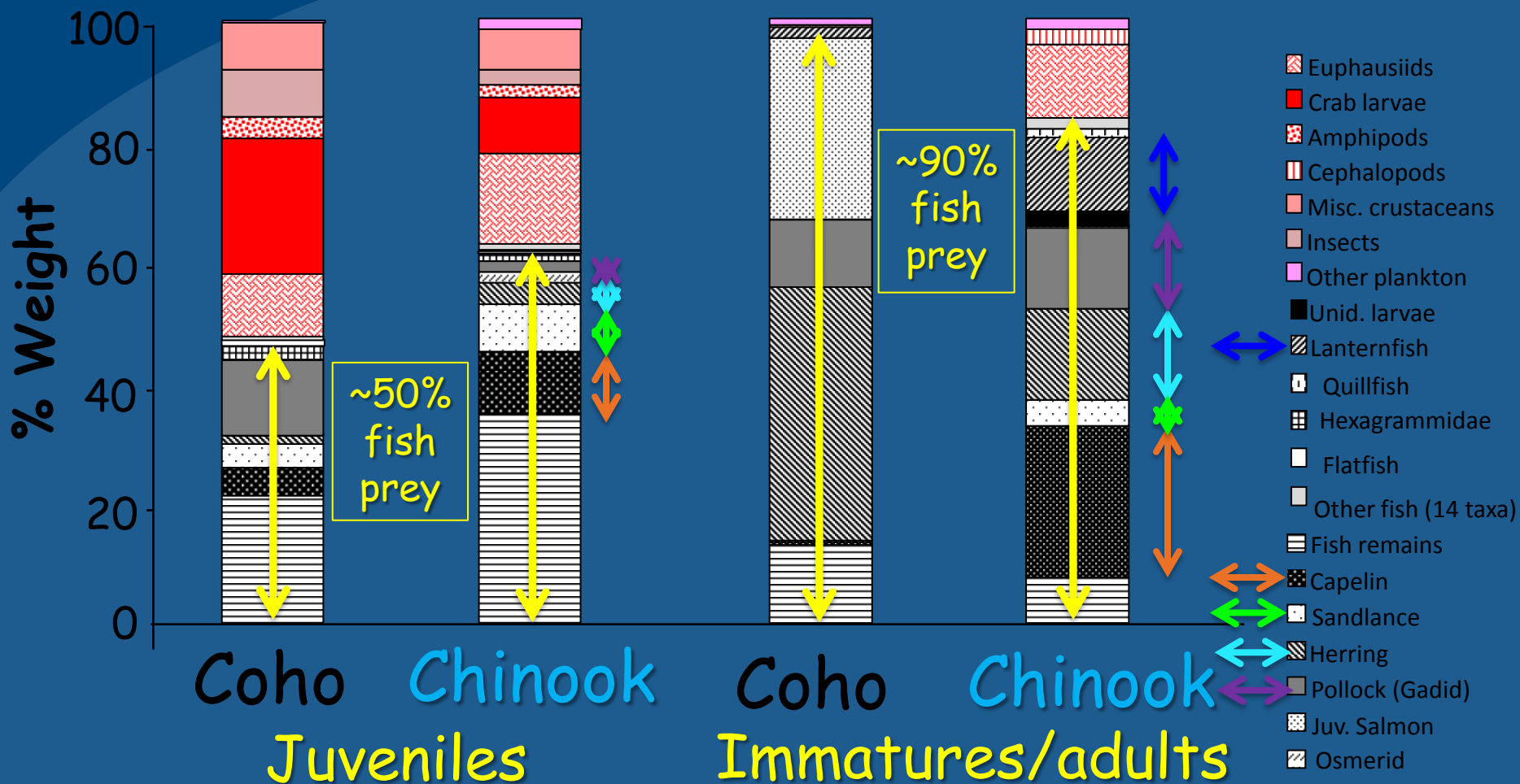
1.6 million fish & squid: 52 fish families - 118 species

Large marine ecosystem	Trawl hauls fished	Total fish sampled	Chinook inshore (%)	Chinook Coastal (%)
Alaska Coastal Current	606	120 K	0.005- <u>0.010</u>	0.002-0.005
California Current	1,510	1,560 K	0.015- <u>0.190</u>	0.007-0.010

Chinook salmon numerically comprised 1/100th
of 1% of the catch in the AK Coastal Current



Diets of Chinook salmon vs. coho salmon in Southeast Alaska



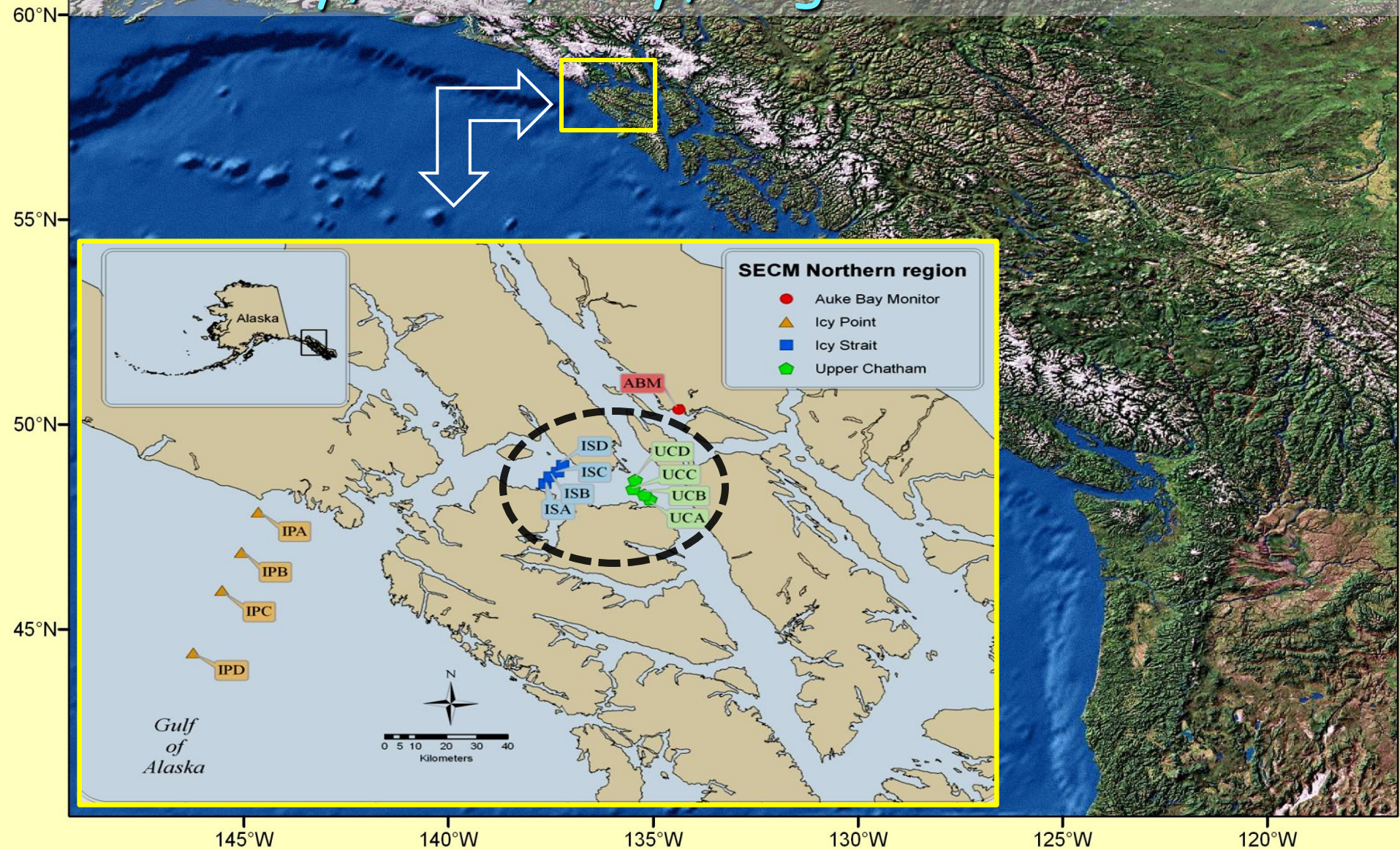
Data sources: Weitkamp & Sturdevant 2008, Sturdevant et al. 2012



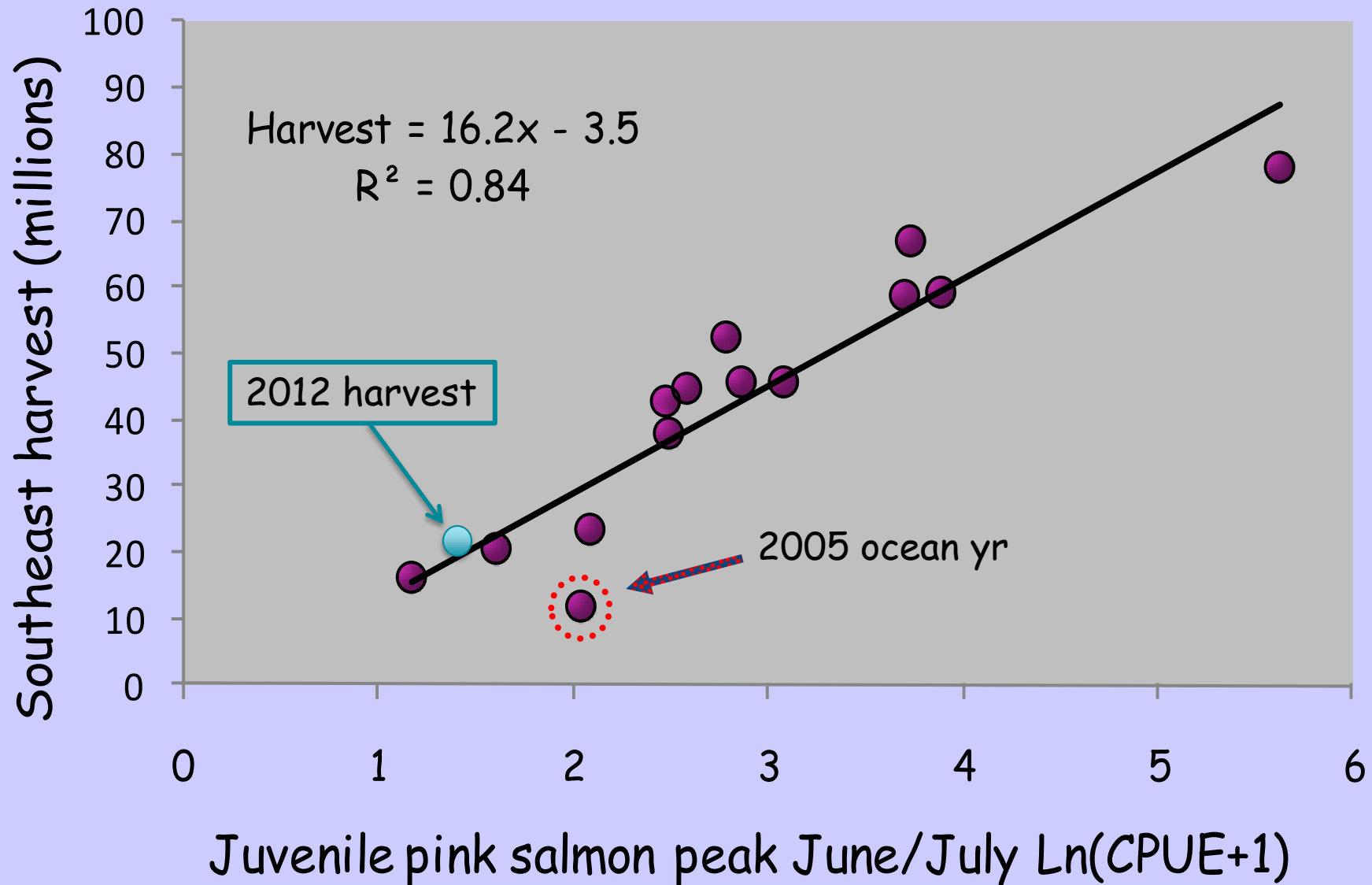
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SECM sampling stations in Southeast Alaska

May, June, July, August 1997-2012



Strong relationship between SECM juvenile pink catch and adult harvest 1998-2011



Diel epipelagic distribution of juvenile salmon, rockfish, sablefish and ecological interactions with associated species in offshore habitats of the northeast Pacific Ocean (Orsi et al. 2006)

July 2005



-5.0 -4.5 -4.0 -3.5 -3.0 -2.5 -2.0 -1.5 -1.0 -0.5 0.00 0.50 1.00 1.50 2.00 2.50 3.00 3.50 4.00 4.50 5.00

<http://www.osdpd.noaa.gov/PSB/EPS/SST/data/anomnight.7.12.2005.gif>



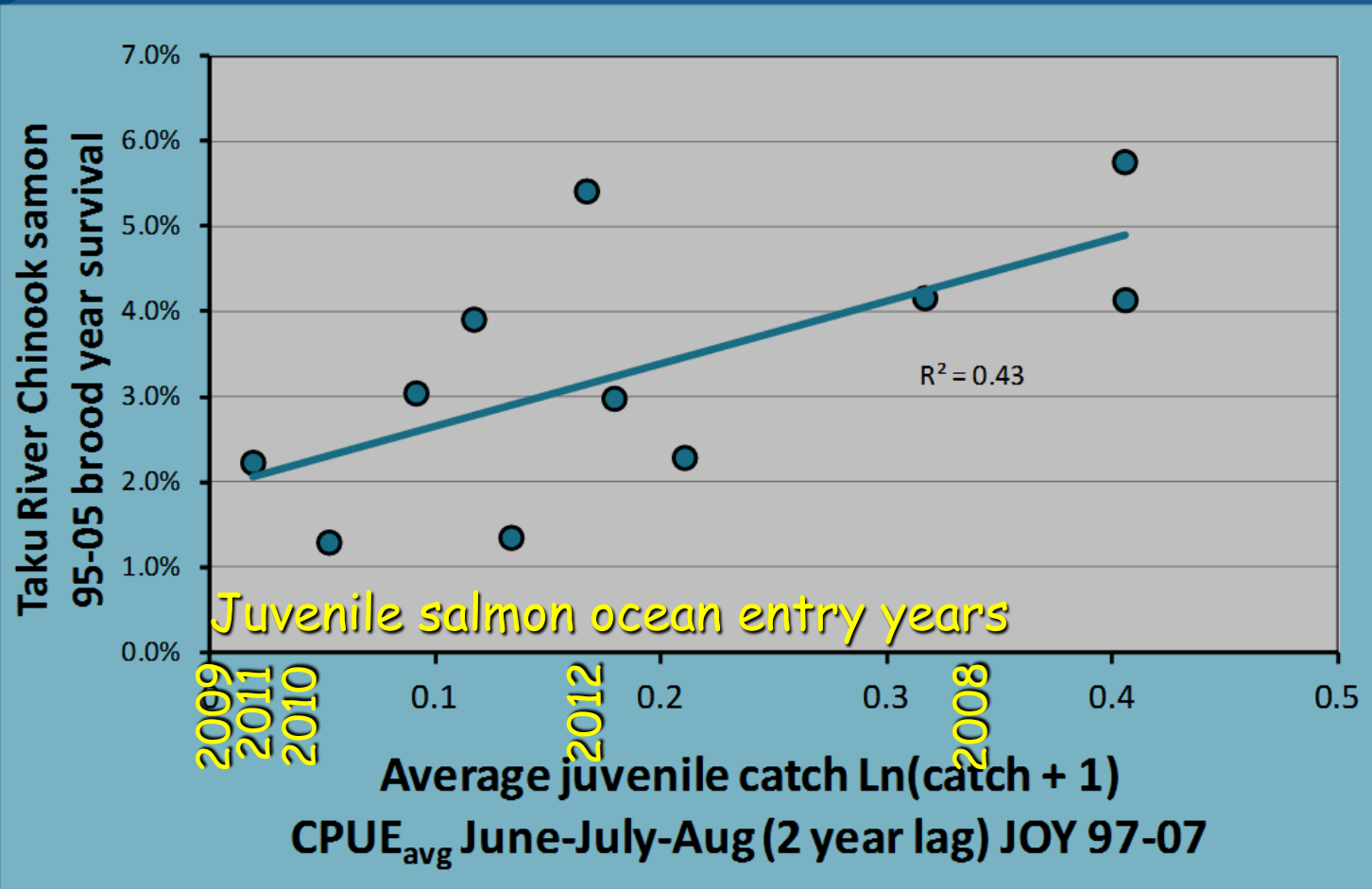
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Correlations between SECM Chinook catches and wild and hatchery Chinook salmon brood year survival

(Chinook data courtesy: E. Jones ADFG, F. Thrower NOAA, C. Blair NSRAA, & R. Focht DIPAC)

Stock-group	Brood years (BY)	# yrs	Age-.0 juveniles $CPUE_{J-J-A}$ (BY + 2)	Age-.1 immatures $CPUE_{J-J-A}$ (BY + 3)
Stikine River Wild	1998-2002	5	0.33	-0.15
Chilkat River Wild	1998-2003	6	0.36	0.53
Taku River Wild	1995-2005	11	0.65 ($p < 0.03$)	0.35
L. Port Walter Hatchery	1995-1999 2001-2005	10	0.01	-0.18
Hidden Falls Hatchery	1995-2005	11	0.17	0.38
Douglas I. P&C Hatchery	1996-2005	10	0.21	0.74 ($p < 0.02$)

Juvenile Chinook salmon CPUE (1997-2007) vs. Taku River marine survival (BY 1995-2005)



Insights from Chinook sampling in Southeast

Catch rates are low with many sampling techniques:
Chinook numerically represent 1/100th of 1% of catches

A multitude of stocks occur in SEAK, some year-round,
migrate northward from distant localities - as age -.1 fish

Many SEAK stocks have limited early ocean migrations as
evidenced by protracted seasonal habitat use, conversely,
some Columbia R. Basin stocks are highly migratory

Deep vertical distribution relative to the other salmon
species, larger/older fish deepest, and seasonally deepest
in winter

Insights from Chinook sampling in Southeast

Juvenile Chinook salmon have habitat-specific seasonal migration patterns, different from the other salmon species

Chinook salmon are piscivores (50-90% of diet), important fish prey are: capelin, herring, sandlance, gadids, & lanternfish

Chinook salmon CPUE shows promise as a tool for indexing Chinook salmon year class strength of some stock groups

Long-term ecosystem monitoring on a seasonal basis has enabled biological signals to be detected

A couple recent studies on Chinook marine distribution and survival...

#1

A refined description of essential fish habitat for Pacific salmon within the U.S. Exclusive Economic Zone in Alaska
(*Echave et al. 2012*)



(Echave et al. 2012)

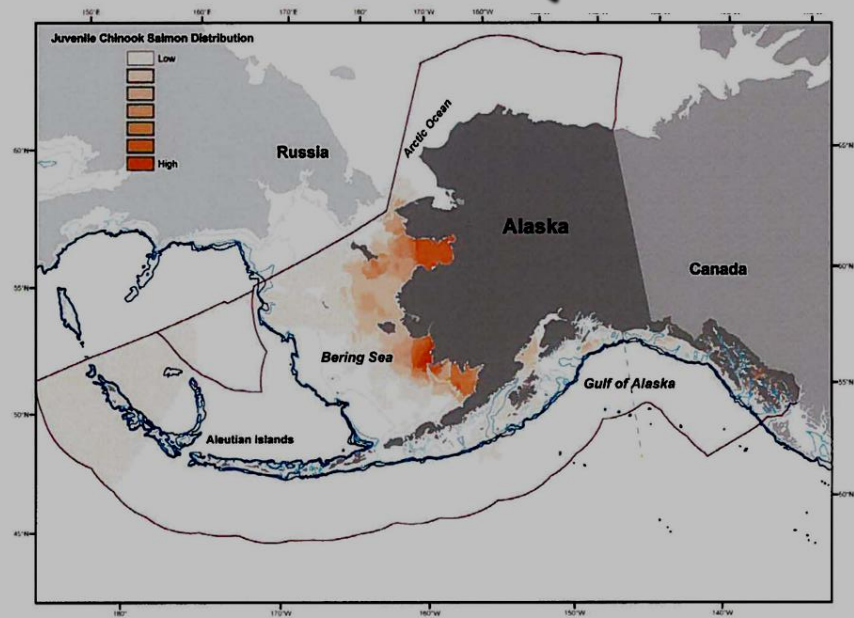


Figure 17a. -- 95% of the spatial distribution of marine juvenile Chinook salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

99

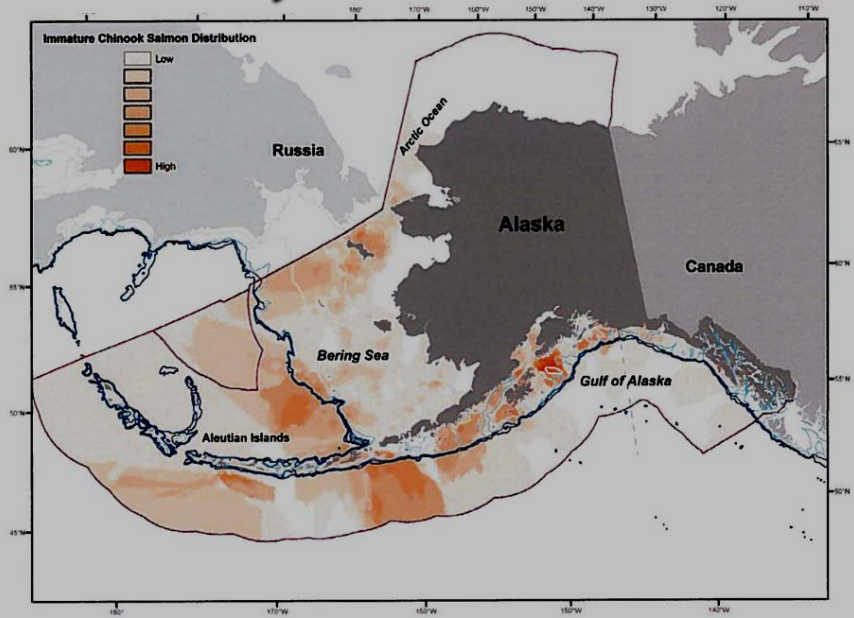


Figure 18a. -- 95% of the spatial distribution of marine immature Chinook salmon range. Smooth line represents the EEZ boundary; dotted line is the Cape Suckling longitude separating East and West Gulf of Alaska ADFG management areas, depth contours are 50, 100, 200, 400, and 600 m.

101

Juvenile Chinook range,
95% of spatial distribution

**Inshore distribution
on the continental shelf**

Immature Chinook range,
95% of spatial distribution

**Offshore distribution in
western GOA & Bering Sea**



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A couple recent studies on Chinook marine distribution and survival...

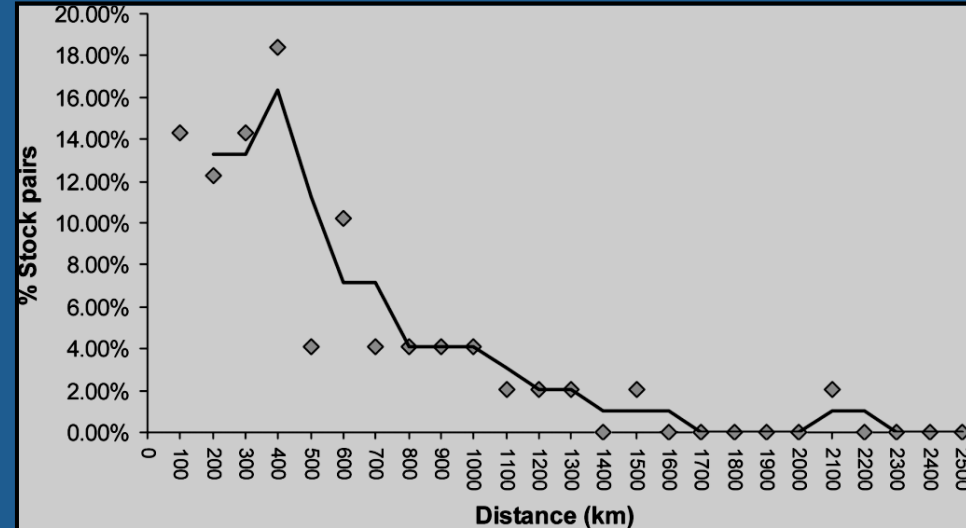
#2

Relating spatial and temporal scales of climate and ocean variability to survival of Pacific Northwest Chinook salmon
(*Sharma et al. 2012*)



(Sharma *et al.* 2012)

Examined smolt-adult survival from 22 Chinook salmon stock groups from the Pacific Northwest to Southeast AK



- Ocean survival grouped into 8 distinct regional clusters
- Chinook survival co varies on spatial scale of 350-450 km
- Local ocean conditions following smolt outmigration had a significant effect on survival for most stock groups



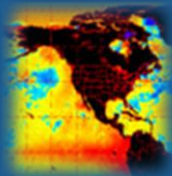
What research is needed to better understand marine production mechanisms for Chinook?



Juvenile abundance?



Climate?



Prey?



Immature distribution?



Competitors?



Adult production?

Predators?



Future Chinook marine research direction?

Monitor ecosystems for index stocks seasonally

Identify stock-specific migration patterns

Do northern Chinook stocks have protracted early migrations, or perhaps two life history strategies: upper vs. lower Yukon?

Do Western AK Chinook stocks migrate seasonally like Japanese chum: summer in Bering Sea/winter in GOA?

Investigate trophic linkages (top-down & bottom-up)

Explore ecosystem metric relationships with survival

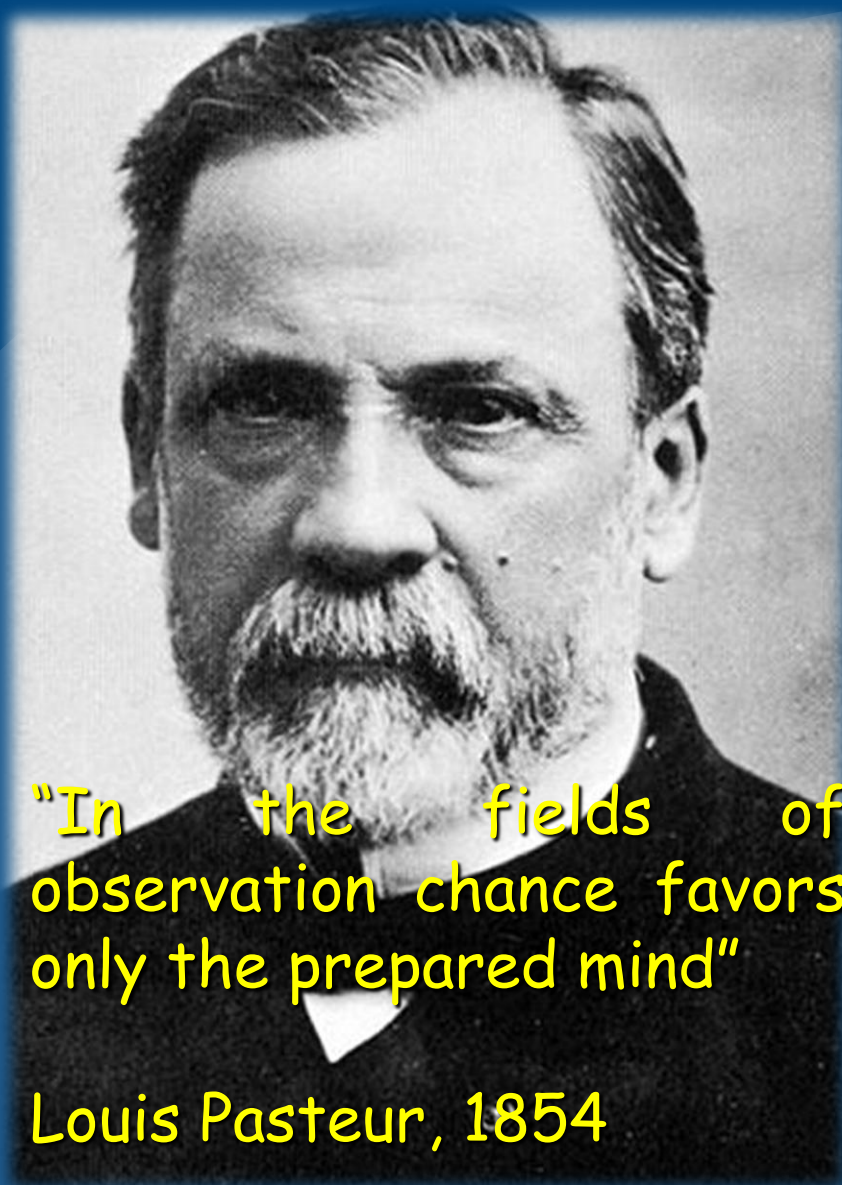
Maintain collaboration among researchers

Thanks for the survey collaboration! ADFG, U of AK, NWFSC, & SSRAA



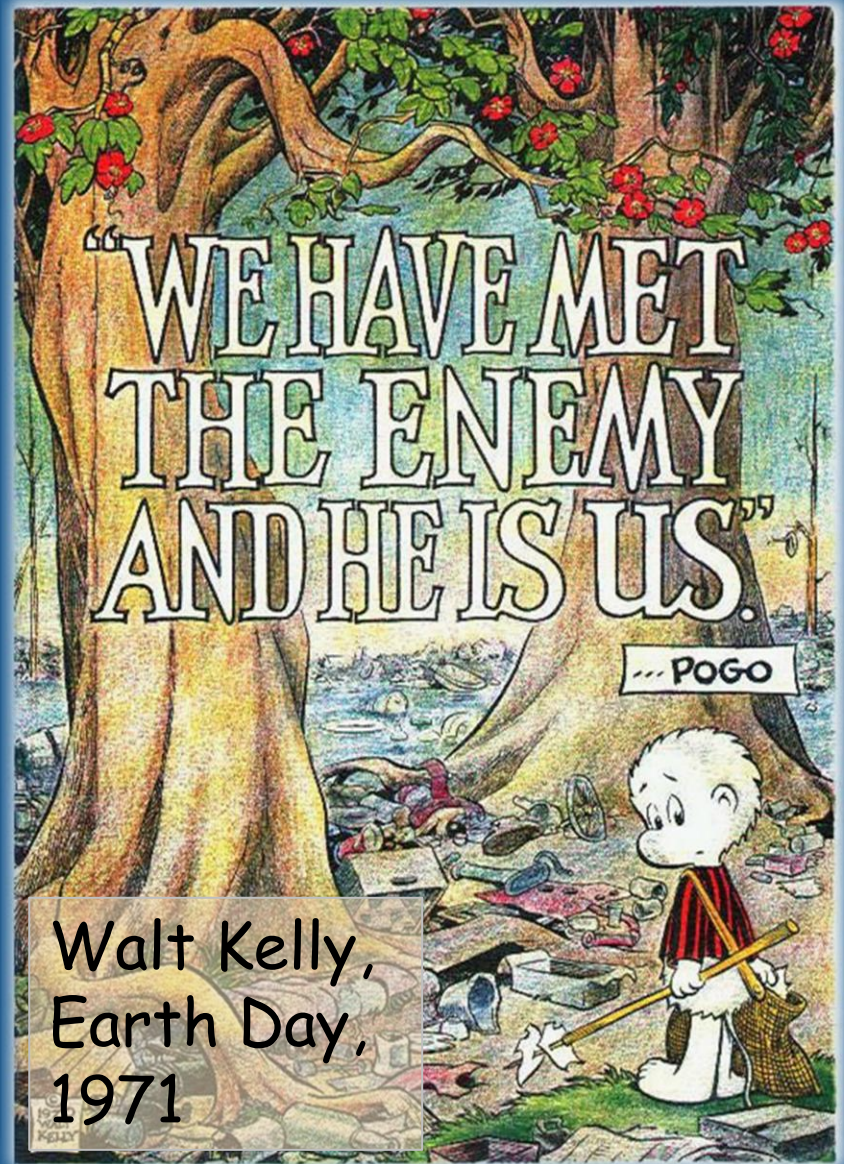
My Chinook Symposium "afterthoughts"





"In the fields of observation chance favors only the prepared mind"

Louis Pasteur, 1854



Walt Kelly,
Earth Day,
1971



My Chinook Symposium "afterthoughts"

1. Where have all the large Chinook gone?
2. Have all anthropogenic effects been considered?

Has there been a cumulative increase in encounter rates of all sizes of Chinook in sport, charter, troll, seine, gillnet, trawl, personal use, or subsistence fisheries?

Is hook-and-release mortality of Chinook fully evaluated?

Does our 28" size limit select against faster growing fish?

3. Is the average size of Chinook declining in AK?

If so, then could a decrease in stock productivity be a result of a negative feedback loop from fish now returning smaller, younger, or having a lower percentage females, thus reducing fecundity of the spawning stock?



Where have all the large Chinook gone?



Fishermen horse seining for salmon, Sand Island,
Lower Columbia River, Oregon, ca. 1900



Where have all the large Chinook gone?



Union Fisherman's Dock in
Astoria, Oregon ~ 1910.
Chinook are 116 & 121 lbs.

In 1933 the Federal Government started dam construction in northern Washington State.

By 1938-9 Rock Island and Grand Coulee dams blocked all fish passage 600 miles upstream!



Where have all the large Chinook gone?



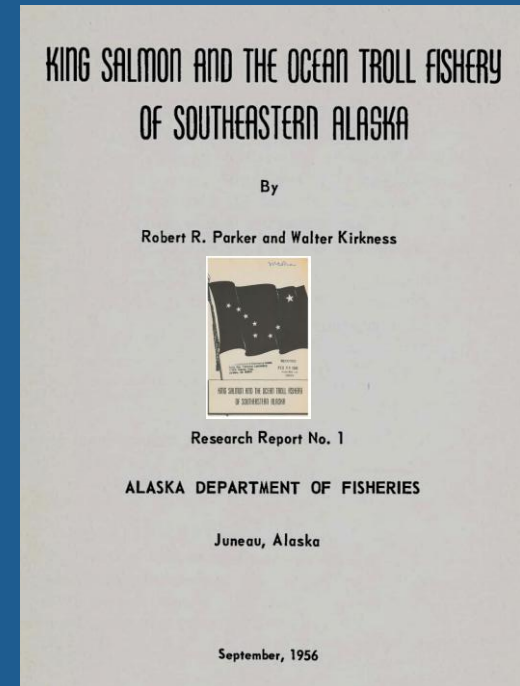
Port Alexander, Baranof Island in SE AK: late 30s
early 40: troll fishery capital of the whole coast



Where have all the large Chinook gone?



Figure 3. Illustrating the method used for handling fish for tagging aboard a troller at sea.



King salmon and the ocean troll fishery of southeastern Alaska. *Parker and Kirkness. 1956. AK Dep. Fish. Rep. No. 1.*

Tagging Chinook off SEAK found most fish to be from the Columbia R.

Trolling for Chinook in SEAK began in the 1900s, peak production was 17 M lbs (dressed fish) in 1937 (Total AK Chinook harvested in 2012 = 4.4 M lbs)



Where the world's largest Chinook salmon is?



Alaska Airlines
"Salmon-Thirty-Seven"





The real world's
largest king salmon
resides at Clausen
Memorial Museum in
Petersburg, AK

126.5 lbs

Caught in the Point
Colpoys fish trap off
NE Prince of Wales
Island, AK in 1939



Anthropogenic effects?

Changes in the average size and average age of Pacific salmon
W. Ricker. Can J Fish Aquatic Sciences, 1981

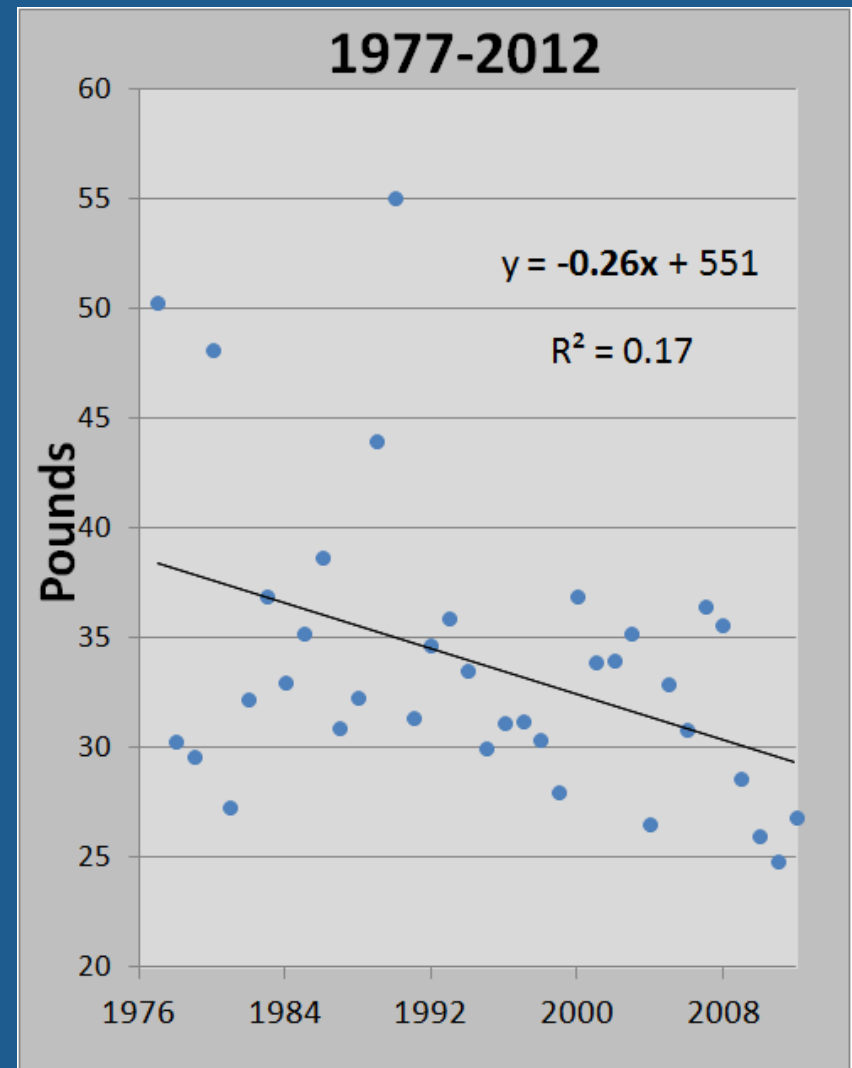
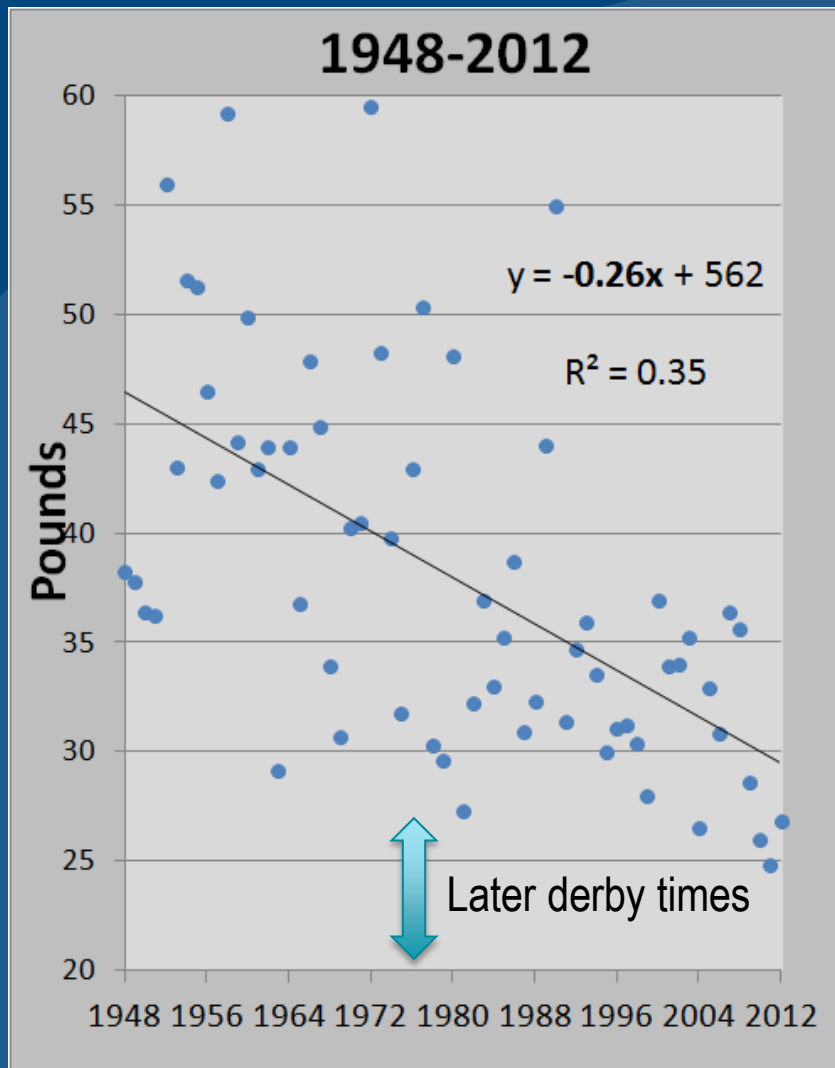
Chinook salmon have decreased greatly in both size and age since the 1920s, most importantly because nonmaturing individuals are taken by the troll fishery; hence individuals that mature at older ages are harvested more intensively, which decreases the percentage of older ones available both directly and cumulatively because the spawners include an excess of younger fish.

Fishing, selection, and phenotypic evolution
R. Law, ICES J. Mar. Sci. 2000

Selection generated by fishing gear is strong in heavily exploited fish stocks, and the spatial location of fishing can also cause strong selection.



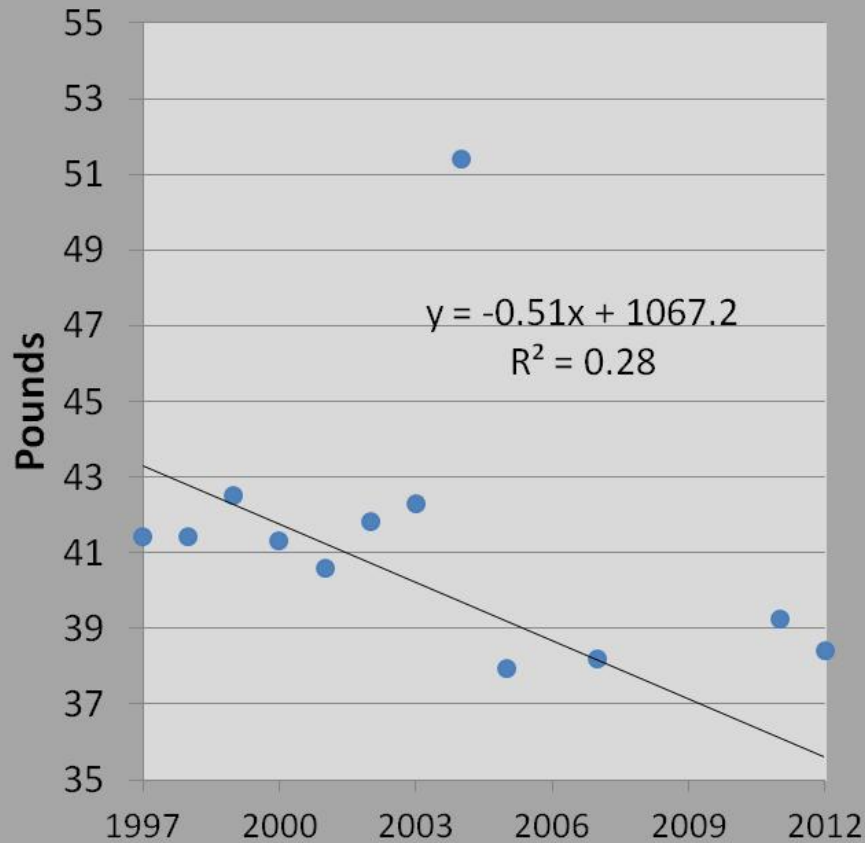
Juneau Golden North Salmon Derby "Winners"



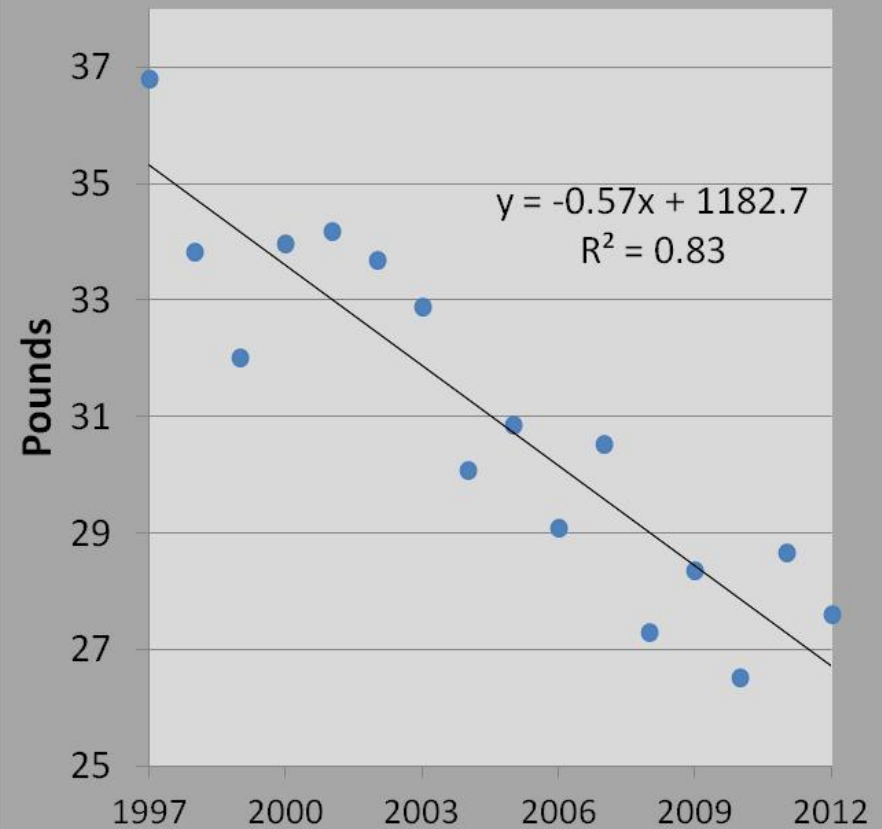
Pearson correlation = -0.59, P-Value = 0.000 Pearson correlation = -0.41, P-Value = 0.013

Juneau Spring King Salmon Derby 1997-2012

Chinook weight (top fish)



Chinook average weight (top 30 fish)

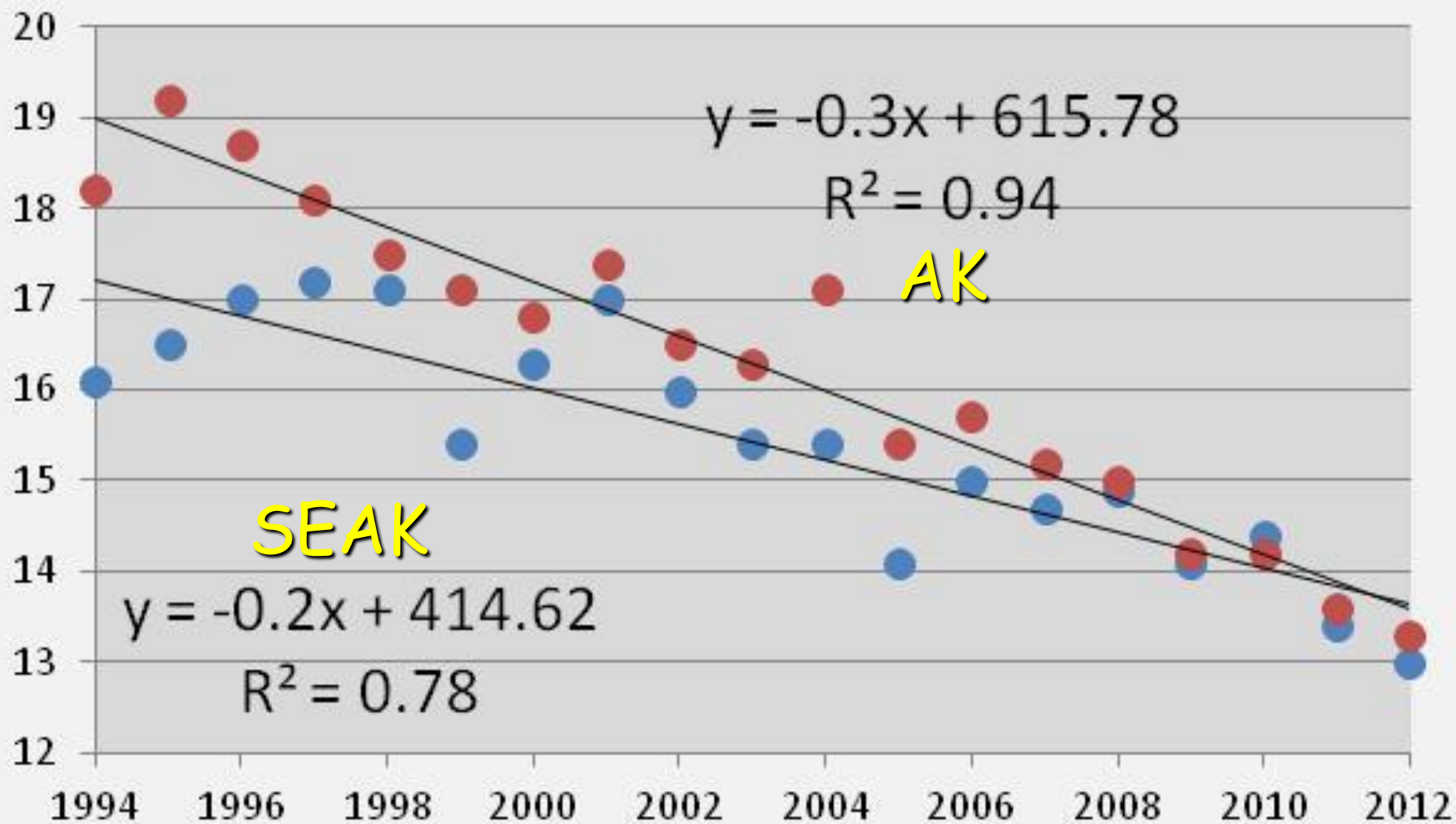


Pearson correlation = -0.53, P-Value = 0.035

Pearson correlation = -0.91, P-Value = 0.00



AK commercial Chinook harvest & avg. wt 1994-2012



Source: <http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisherySalmon.exvesselquery>



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Importance of Assessing Population-Level Impact of Catch-and-Release Mortality

Kerns, et al. 2012. AFS FEATURE Fisheries Science

"Many studies have measured the mortality of fish that are recreationally caught and released (i.e., catch-and-release [CR] mortality); however, little work has explored methods to understand the cumulative impact of CR mortality on fish stocks."

"Common snook have relatively low CR mortality (~3%), but due to increasing fishing effort, about 35% of the total fishery-related deaths are attributed to *F_{cr}* (Muller and Taylor 2006). "

"Many recreational have high release rates of fish that are legal to harvest; thus, traditional measures of *F_h* may not indicate the full impact of fishing on fish abundance, size, or age structure."



Does the 28" size limit select out faster growing fish?

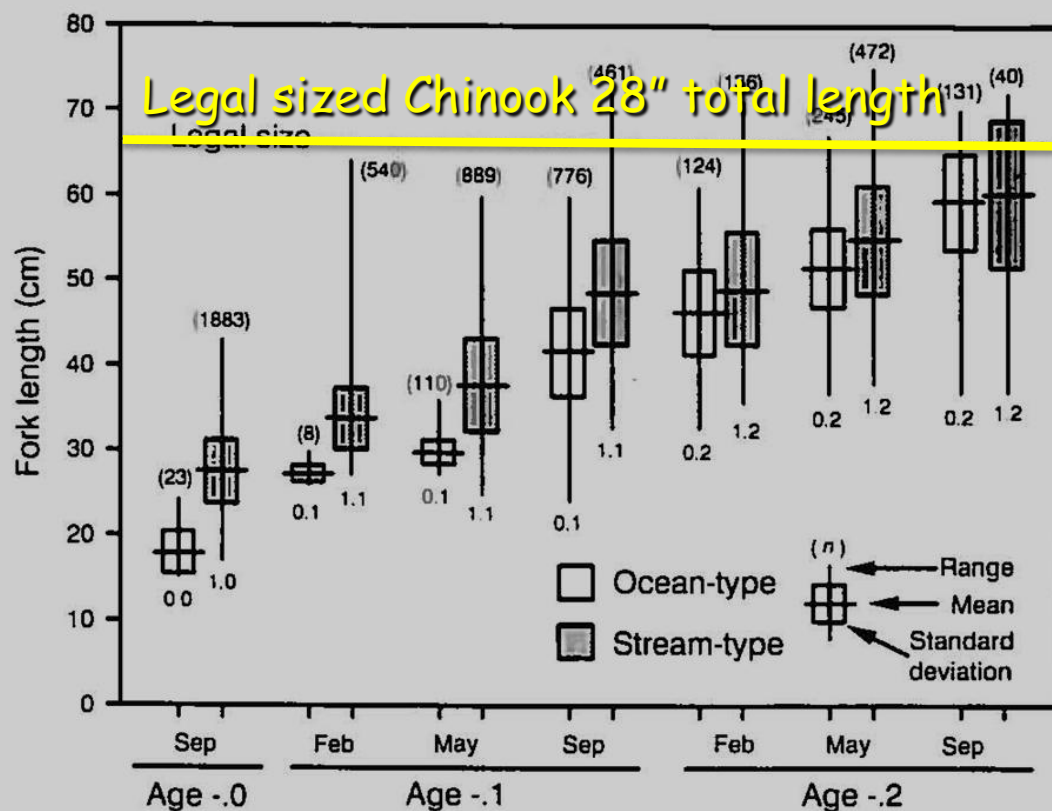


Figure 3

Length at age for ocean- and stream-type chinook salmon, *Oncorhynchus tshawytscha*, sampled in marine waters of south-eastern Alaska during February 1987, May 1986–87, and September 1986–87. Sample sizes are in parentheses.

Note that the faster growing age 1.2 Chinook reach the 28" size limit ahead of their cohort.

Have we been inadvertently selectively removing the faster growing age -.2 fish?

Final “afterthought”

We should examine our existing long term data sets on age, size, and sex composition of Chinook salmon to see if present day stocks are smaller, younger, and less productive

Inter- and intra-population variation in the fecundity of Chinook salmon (*Oncorhynchus tshawytscha*) and its relevance to life history theory.

Healey and Heard 1984. Can. J. Fish. Aquat. Sci.

“Large body size may be advantageous for females because of the success of larger fish in establishing, digging, and protecting their redds”



Thanks for the survey collaboration! ADFG, U of AK, NWFSC, & SSRAA



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